ROLE OF HUMANOID ROBOTS IN ENHANCING COMMUNICATION AND SOCIAL SKILLS AMONG STUDENTS WITH MILD AUTISM

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by

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Abstract

Introduction: Children with autism spectrum disorder (ASD) face challenges with social interaction and this has become a growing concern. These challenges if not addressed, can cause further isolation resulting in displaying anti-social behaviors. Children with autism are inclined towards technology and the use of assistive technologies in special schools have shown promising results in bridging learning gaps. Most literature have shed light on the positive impact of emerging and assistive technology on their learning, however the use of emerging technologies special tutors to build vital skills amongst children with autism has not been much explored. This makes it area of research that requires attention.

Objectives: This study aims to explore the benefits of using humanoid robots, latest emerging technology in inclusive class settings develop social-communication skills among students with mild autism. The study will shed light on whether robots can effectively address children's social communication skills thereby contributing towards the child's speech and behavioral development.

Methods: Mixed method research design involving a combination of qualitative and quantitative tools was incorporated to explore this phenomenon. In this study, the researcher conducted semi structured interviews with special tutors and counsellors to gain insight into the benefits of child-robot interaction. This was instrumental as they a key role in facilitating the interaction and monitoring the progress over a span of one year. Focus group discussions were conducted pre and post lockdown with parents to understand the application and transfer of skills learnt through robot interaction in various social settings along with understanding the impact of online education on these students during the pandemic. The researcher observed the social skills training program undertaken by the school. Single group pre and posttest was also conducted to evaluate the effectiveness of the social skills training program devised to systematically enhance social communication skills of students with mild autism between grades 10-12. The course was executed by special tutors and a humanoid robot over a period of two months and interrater reliability approach was adopted to validate the scores

allotted in the social communication questionnaire scale (SCQ) during the observation period.

Results: The findings from this study have shown the positive effects of humanoid robots on the social communication development of students with mild ASD which includes preparing them with social skills for the future. The sample showed improvements, including application of skills in specific social settings.

Key Words: Autism Spectrum Disorder, Humanoid Robots, Social-Communication skills, Special Educational Needs, Inclusive Education.

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INTRODUCTION

Emerging technological and recent innovations in the field of education have increased educational productivity. It can cater and meet the needs of auditory and visual learners thereby fostering student engagement. Top notch technological innovations such as virtual reality and artificial reality have steered academic rigor by accelerating learning, motivation and offering several promising outcomes along with opportunities for different style of learners. These emerging technologies encourage communication, personalization, collaboration, and inclusive education as a result enhancing the traditional ways of teaching (Brode, 2005).

In recent years, technology has become a necessity in the field of special education to prepare them for the future. Special educators have made conscious attempts to incorporate computer and information technologies to enhance the teaching /learning process. Assistive technology refers to the technological devices and platforms custom made to improve, increase capabilities of students with disabilities. Assistive technologies range from low technologies like computers to complex technologies such as text-to-speech applications, game-based learning, and robots to meet the needs of learners with learning disabilities. These emerging assistive technologies promote equity in education and profoundly help students with disability meet their goals listed in the Individual Education Plan reports (IEP). Inclusive education is an upcoming model of education promoted and followed by most International Baccalaureate (IB) schools globally. The IB curriculum policies empower all students to learn and take exams under fair conditions by this means eliminating bias and stigma.

Joyful Inclusion, developed based on the UNESCO statement in the manual for teachers to develop a classroom for all, is a pioneering model in which general teachers play a vital role in inclusive education. It addresses the common misconception that needs to be dispelled, that the presence of disabled children in classrooms impedes the learning of non-special needs children. It was initiated with an objective to scale up primary education in rural areas for children with special needs in 1998 (UNESCO, 2010).

Today the nature of innovations in the field of assistive technologies have widened. Alternate forms of communication like humanoid robots propose solution-based strategies and personalized curriculum. While most educational technologies are directed towards increasing active learning, very few technologies offer the capability to improve skills of children with learning disabilities and impairments. Transferring essential lifelong skills continues to be a challenging area particularly in the context of autism spectrum disorders. Recent media technologies have been able to address this barrier making it a potential area of research.

Artificial intelligence in a classroom setting involves machine learning that is made up of a range of hardware and software and designed in conjunction with children, researchers, parents, and teachers. Elements include a large multi touch screen, two webcams for detecting gaze and facial expressions, a virtual character that uses artificial intelligence to react to children's actions in real-time; gaze and touch tracking software that informs the environment's reactions to the child; social signal processing and user modeling software (Prat, 2019).

Initial observations from a recent study of attention and gaze following in children on the autism spectrum showed that they were able to learn to follow gaze cues or communicate with the character and that they treated the virtual character as an agent and as an equal partner in the interaction. Children showed improvement in the sustained focus of attention, anticipation as well as knowingly searching for interaction cues from the virtual character (Aldebaran, 2019)

Taking into consideration these core deficits, some of the major benefits that AI possess for students with ASD are expanded opportunities for learners to communicate and collaborate with each other and greater interaction between learners and academic content (Karsenti, 2019).

Need for the Study

Children with autism have trouble developing language and communication skills. Autism spectrum disorder (ASD) is a developmental disorder also known to be social communication disorder. Both social communication and interaction is a fundamental challenge associated among this group of children. Special tutors

consciously train students with autism as they have poor non-verbal skills and often feel awkward in social situations and maintaining eye contact.

Often children with ASD display no appreciation for the feelings of others. Even when children with ASD learn appropriate words to say, they may display unusual body language when communicating. They do not engage in or maintain eye contact or even face their communication partners. Their intonation, voice volume, and cadence may be unusual and may not match the situation. Sometimes, their impaired ability to understand the context of social interaction will cause them to react in unexpected ways (Keohane, 2013).

They are unable to make friends, learn from the outside world, develop hobbies or interests resulting in troubled family relationships and lacking a sense of belongingness. Special educators tend to focus on building four skills to work on the social deficits i.e., play skills, conversational skills, emotional skills, and problem skills (Murdoch, 2006). Children with ASD learn to communicate and speak in a different way and not in a simple delayed manner. They communicate using the triadic communication using eye gaze, gesture, and object, they are known to use language as a last resort. Most of the children falling off the spectrum are visual thinkers who think using visuals and not language. They are very good at paying attention and appreciating visual materials. Hence visual routes are taken by special educators and therapists to enable the child to express themselves. Since the ability to communicate is often associated with intellectual and social development, children with ASD lack the ability to respond to the speech of others (Puri, 2004).

Most educational technologies have been blended in classrooms, to increase student engagement, critical thinking, problem solving etc. There has been a lack of focus on skill development in the context of special needs. Children with special needs are often trained to access content easily, learn and retain better using assistive technologies. While these technologies have shown great results in tailoring education, the current study aims to explore the role of emerging technologies in facilitating skill enhancement and preparing students with autism for the future. The study adopts a mixed method approach to evaluate humanoid robots and its role in imparting skill-based education.

Humanoid robots can act as social robots enabling students with autism to communicate and collaborate in small groups gradually. Since the area is under researched, the study is designed to explore the impact of this latest emerging technology on improving the social and communication skills of children with mild ASD and in what ways does the medium assist them reach goals documented in the IEP.

REVIEW OF RELATED LITERATURE

Children with ASD have difficulty using social communication. They may have deficits in "abnormal social approach and failure of normal back-and-forth conversation, reduced sharing of interests, emotions, or affect; to failure to initiate or respond to social interactions" (Abel, 2013). Because of these deficits, children with ASD require varying degrees of support in social communication—requiring support, requiring substantial support, or requiring very substantial support (Abel, 2013).

At the lowest level of support- requiring support, children with ASD who require support may have trouble initiating conversations and responding appropriately to a communicative partner independently. When engaged in conversation, children can use full sentences but have difficulty taking turns during conversation. Children with ASD who require substantial support may have trouble with both verbal and nonverbal social communication, which is demonstrated by their difficulty initiating and maintaining a conversation. Further, these children use a limited range of topics during conversation and markedly odd nonverbal communication. Children who require very substantial support may experience limited social interactions and provide minimal responses during social interactions. These children typically only communicate them needs. Difficulty with social communication inhibits these children's ability to have interpersonal relationships (ASI, 2012).

The nature of technology has emerged, and Artificial Intelligence in Education (AIE) is the new technological advancement that has been conceptualized in the 21st centuries. In the realm of special education has created powerful learning environments and to increase positive interactive experiences among learners. It has strengthened areas that involve knowledge representation, tutoring, one on one mentoring, natural language processing and ownership of content (Drigas, 2017).

The introduction of AI in special schools globally has improved the lives of those people with special educational needs. There has been more emphasis on skill development, hence preparing them for the outside world. The style of education through AI promotes collaborative learning that involves interaction and contribution hence facilitating meaningful engagement (Eleni, 2012).

Use of AI among children with ASD has been very effective. Emotion recognition computerized tool based on joint visual and audio cues help them interpret emotions. Since these children have problems with speech, social skills and emotions, computer application programs like these have helped strengthen skills. The application enables learners to identify 6 universal emotions alongside emotions like confusion and frustration, it indicated such emotion recognition accuracy can be improvised with the use of audio and video cue information disseminated through AI (Sebe, 2006).

Adolescents with high functioning ASD were exposed to an AI designed platform, a social scenario game, where they were able to rehearse and learn social skills through imitation and modeling. This training has been offered with reduced help from parents, counselors, and special educators (Smith, 2019). High levels of comfort have been exhibited towards technology among children with ASD. Particularly AI has been able to provide a predictable, logical, and intellectual outlet with specialized interests, especially social skills. Social robots with a predictable range of human emotions have played a crucial role in making children with ASD more comfortable. The more time these children spent with social robots, they were observed to socially integrate better with other people (Caroline, 2012).

Virtual reality and Artificial Intelligence have been useful for particular developmental disorders. Children with ASD can practice skills safely in these platforms without experiencing any potential harm. These technologies have paved the way for such children to learn and practice a series of skills that are essential to living an independent life (Parsons, 2018). People with ASD have lacked a training space that could help with their reskilling. Hence technologies like AI and VR have offered a stable and safe environment in which practice and interaction can take place without inducing anxiety.

In India, AI application tools have been a breakthrough by enabling special learners to help them communicate better and improve learning through fluidic styles of content delivery. One of the outcomes observed during this training is the emergence of empathy. It was observed that with communication, AI helped support their emotional bits of intelligence (Vashist, 2019). These empathy-based games, programs, and applications are intended to counteract the consequences of digital ubiquity and lack of social engagement (Randell, 2018).

Prominent skills that have been imparted to children with ASD through a classroom are mimicking, matching, recognizing, understanding, and observing. The algorithm embedded in the AI programs has helped cultivate many skills, particularly fields where there is a deficit (Marian, 2015). Children with ASD having speech disorders have been treated using the potential of AI. A system titled "Computer-Based Speech Therapy" was designed to provide therapeutic actions for each pupil affected with communication-based on selected information (Schipor, 2003). Every student with ASD requires support at their own level for their specific needs. Some of the prominent areas that require support include reading, writing, and spelling abilities. Two computational methods of training children with handwriting were created, were AI dealt with difficult standards of recognizing handwritings including writing skills of children (Srihari, 2008).

Interpersonal skills like active listening, presentation, cognitive skills like problem-solving and critical thinking, and intrapersonal skills ranging from adaptability to self-management are crucial skills for any 21st-century citizen. In the case of children with ASD, two AI techniques namely Dialogue systems and Inquiry systems are integrated into the curriculum to help build strong dialogue and communication systems. AI can determine and interpret the tone and inflection to provide continual feedback in the dialogue systems. These intelligent tutoring systems can assess and build on the tone, facial cues, body language and speech rate of students with ASD. The inquiry systems aim at supporting learner's ability to question and enhance their understanding through networking and collaboration (Kopeinik, 2017).

Most AI technologies use ubiquitous computing to create social learning and train social skills among children with communication or any skill impairment. Due to which they have contributed significantly to the education of children with special

needs. The areas that have been worked on using AI include communication and social skills which further has helped in increasing attention span and concentration. With the use of Natural Language Processing applications for children with special needs, it has shown slight improvement in their communication skills because of the interaction with the application like they were speaking to a human. Embodiment is a strong feature used in AI pedagogical tools (Marcelino, 2018).

Students with ASD respond comparatively well to technology as opposed to human inputs. It is observed that they orient themselves more easily towards objects than to people. AI is the most responsive technology and social robots have been implemented in schools to teach them social skills. The idea is that since ASD children are more comfortable around computers, and by extension robots, they are learning key social skills in a manner that feels safe and predictable for them (Holz, 2017). These social robots have sensors, cameras, and facial recognition software to capture a child's responses and evaluate progress.

AI has improved the quality of special education in India. Often a neglected domain, the use of AI and machine learning has helped in predicting the academic and non-academic support these children may require. Students' performance for skill development and training have been continuously assessed. There is scope for providing tailormade and customized content based on learning and training goals. Employability is a key concern for students with special needs and AI has been used a lot in skill development and placement. By using Artificial Intelligence, institutes may find the ideal job sector for a student and may provide targeted training to the student for him or her to be successful in the sector, something that was not possible earlier (Indiatoday, 2019).

The embodiment of the robot is also a critical factor in the learning activity of specially abled children. (Boladeras, 2012). Robots also act as a bridge in enabling specially abled students to understand humans. Students can learn how speech is processed by humans by considering how robots recognize speech. One of the major shortcomings in the area is the absence of a well-defined curriculum and learning material for special educators. Robotics education for special needs is still seen as an extracurricular activity and a part of informal education (Movellan, 2008).

For students who may not be motivated to attend traditional, auditory-based classroom learning, AI has “intuitive, interactive features that are appealing”. Students with communication, developmental and cognitive problems can utilize built-in features to touch, swipe, listen, manipulate, explore, navigate, and even take virtual walks around a concept. students can be directed to utilize apps to increase skill development in multiple domains for documented needs, such as fine motor and social skills learning, leading to increased skills and independence (Jesness, 2012).

Robotics could be a feasible assistive tool to facilitate and enhance students’ learning process. it serves as a tool to develop cognitive and social skills for students and enhance the learning of school subjects or interdisciplinary activities. AI can be a strong management and motivational tool for students with learning and developmental disorders (Kazakoff, 2013). Experiential learning theory, constructivist learning theory, and joyful learning are found to be effective in the application of AI in inclusive or special classrooms. The learning process with the students required teacher’s scaffolding such as asking questions, focusing attention, giving direction, dealing with frustration, giving information, and helping to tackle difficult problems (Slagen, 2011).

From the studies, it can be inferred the use of AI in the special education scenario is still a new approach in Indian education that is yet to be explored.

Objectives of the Study

1) To examine the effectiveness of humanoid robot interventions in classrooms to assist students with mild autism through their social interactions.
2) To evaluate the special educators and parents’ observations on the use of humanoid robots in academic settings to teach communication and social skills.
3) To understand if artificial intelligence can act as viable platforms to enhance skills and abilities in the context of autism special education.

METHODOLOGY

The study follows a mixed method approach to give voice to the study participant and primary – secondary caregiver who are closely connected with the sample. As a result of this research design, the study is deeply grounded in the participants' experiences. Since the media technology under study here, humanoid

robots, is still emerging, there is limited literature focusing on the advantages of humanoid robots for children with mild autism. Hence, the current study combines elements of qualitative and quantitative research to explore the research objectives.

Case study

It is a detailed holistic investigation of a person, group, or a phenomenon. Case study is a method used in research methodology that involves in depth analysis of a case or situation. The case can be further seen as a phenomenon, an event, an issue, a population. It is a commonly used research tool in social sciences particularly when the issue revolves around the domain of education (Gulsecen, 2006).For the study, instrumental case study method was adopted as it enables the researcher to understand more than what is initially obvious to the observers, it allows the researcher to study a specific community that facilitates further understanding and redraw generalizations (Mills, Durepos, & Wiebe, Eds. 2010; Stake, 2006). It is commonly used in the field of education and the method provided the researcher with additional opportunities to learn more about the sample. The instrumental case study is conducted as a pilot study, where most of the data is gathered through observation, interviews with parents, faculties teaching the sample, Counselors working on the samples IEP report.

Semi structured interviews

The researcher developed an interview guideline based on prior studies and literature available on the chosen topic, framing questions that will generate detailed information on specific areas that needed further exploration. Therefore, a set of 24 questions was developed by the researcher pertaining to the objectives of the study. In this context using a semi structured interview allowed the researcher to pick up cues from the expert responses and employ open ended questions to spontaneously probe certain concerns that might help one gain more insight into the impact that AI has on children with ASD through the coherent responses they offered.

The researcher also conducted in-depth interviews with experts from the field to give a psychological perspective to the study. The researcher has looked at the experts as an authority figure to provide insights to the unexplored area of study. The questions focused on the interest area of the study and was broad, open-ended questions were asked that helped construct relevant answers.

On interviewing the sample, the researcher transcribed the audio material and further developed themes related to the robot teacher and skill enhancement using thematic analysis. The researcher proofread and read through the text several to identify the key phrases used in the narrative. The researcher has also identified the sample's expression and quotes, arranged the same into content that can go together. The Key Words in Context (KWIC) approach was also adopted to verify and validate the data derived from the thematic analysis. The key words in the transcribed text have been identified, followed by systematically searching for contexts where the words have been used.

Focus group discussion

The researcher conducted two separate online focus group discussions with parents of the students profiled in the pilot study. The focus group discussion was conducted before and after Covid 19. The researcher opted for online focus group discussion as systems across the world were shut due to the COVID 19 and interpersonal communication was restricted. Verbal consent was taken from the parents of the participants and faculties during the ongoing online classes and forms were mailed to document the consent. Sample insisted that no discussions should be recorded since sensitive information such as issues with classes, faculties, administration, and technology were part of the discussion. Hence, the researcher resorted to making field notes by also using an assistant.

The focus group discussion for each question went up to maximum 1 hour 53 minutes with parents followed by faculties giving their perspective if online classes really help bridge the gap and meet the needs of children with special needs. 10 Parents of the selected sample of students were questioned on how their children cope up with online classes and if there is a change in the approach to online classes conducted by teachers versus being in a class with a robot teacher.

Information noted from both ends in terms of verbal and non-verbal details were analyzed and then a noted based analysis of the information was conducted to code the information into categories. Likewise, here the same Key Words in Context (KWIC) approach has been adopted to understand the data from the interview. The key words in the transcribed text have been identified, followed by systematically searching for

contexts where the words have been used. A matrix was also created to assess the level of consensus both verbally and non-verbally from the respondents.

Observation method

Robotic classes designed to teach students social and communication skills were obsessed by a team of four tutors including the researcher and three therapists for a duration of six months. The course was designed keeping in mind to address and improvise on the deficits listed in the IEP report of each student under the category of communication. The observation method was used for purposeful examination of the teaching practices and student engagement in the resource classroom with the teacher and robot.

To test the effectiveness of the robotic intervention on autistic children's social and communication skills, the Social Communication Questionnaire (SCQ-Teacher's version) was used. This scale is standardized and popularly used in the context of an educational setting by the principal caregiver, teachers, and tutors to assess the social communication skills along with behavioral problems. Formerly known as the Autism Screening Questionnaire, this tool was created specially in the context of an educational setting to observe and quantify specific social and communication deficits of children with ASD. This scale is a brief 40 item screening measure in which each item is measured using a yes/no response by the primary caregiver or parent who is familiar with the child's development and behavior. Items came from the Autism Diagnostic Interview Revised (ADI-R), which is considered the "gold standard" measure for gathering developmental history related to ASD.

All the relevant socio demographic information and test scores were consolidated in Microsoft Excel and transferred to SPSS trial version 16.00. Inter rater reliability approach was adopted to validate the findings of the observation. All the scores issued by the raters was fed into SPSS and Paired T test was conducted to see the extent to which the robot induced socio-communication skills among the sample.

Sampling technique

Convenient sampling technique was used in the current study. The researcher chose a school in Bangalore that follows an IB curriculum, practices inclusive education and has access to AI powered robots. Since the study follows a mixed method approach, a sample of the 13 students diagnosed with mild autism were chosen for the observation. The sample was chosen from an international school located in Bangalore practicing inclusive education known for introducing India's first AI powered humanoid robot named Eagle 1.0. Additionally, parents of the students chosen for the study along with their special educators, therapists (expert panel) were contacted for semi structured interviews and focus group discussion. This style of sample fit best to the study as all the data and sample was being drawn from that part of the population that is close to hand.

DATA ANALYSIS

Case study method

Before stepping into the observation, data profiling technique was adopted by the researcher to gather as much data, with an intent to have a better grasp of sample's gaps and strengths. Profiling refers to an analysis and recording of an individual's behavioral and psychological characteristics to evaluate their potentials and capabilities in each area and aid in areas required. A descriptive case record of each sample's background, strengths, weakness in the context of Autism and Communication was recorded. The case study contains elaborate pointers from examiners about the child's past and current struggles with academics and skillsets. Learner need analysis was further used to narrow down the specific strengths and weakness before the robotic sessions.

The summarized data in the case study has been procured from existing sources that includes class observation, interactions with parents and faculties, counselors directly dealing with the sample, IEP reports. All the students in the sample frame for the case study have undergone a psychometric testing and clinical testing for ASD further which IEP reports that are confidential, have been drafted by the counselors for each student.

Table 1: Participant Descriptions

Sl No	Participant Initials	Grade	Gender	Ethnicity	Severity
1	JC	10	F	Asian/Indian	Mild Autism
2	SM	10	M	Asian/Indian	Mild Autism
3	GG	10	M	Asian/Indian	Mild Autism
4	RS	11	M	Asian/Indian	Mild Autism
5	MD	11	M	Asian/Indian	Mild Autism
6	SD	11	M	Asian/Indian	Mild Autism
7	PH	11	F	Asian/Indian	Mild Autism
8	PV	11	F	Asian/Indian	Mild Autism
9	AM	12	M	Asian/Indian	Mild Autism
10	VK	12	M	Asian/Indian	Mild Autism
11	PB	12	M	Asian/Indian	Mild Autism
12	SJ	12	F	Asian/Indian	Mild Autism
13	AS	12	F	Asian/Indian	Mild Autism

All the students in the sample frame with special needs have their progress and transitions tracked and evaluated on a trimester basis using the Kauffman Test of Educational Achievement Second Edition (KTEA-II). Along with the KTEA, each student with special needs in the class, has an Individualized Education Program (IEP) report maintained by the faculty, special tutor in consultation with the counselor. The report entails the services that are going to be offered, areas of development, goals set by the end of the academic year to be achieved. As per the Individuals with Disabilities Education Act (IDEA), it is a mandate for educational institutes to provide “appropriate public education”. Most institutions following the IB and IGSCE board adopting an inclusive learning approach should maintain an IEP that is confidential. The document can be accessed only by the parents, special tutor, faculty in-charge and the counselor.

The IEP is a confidential report that contains aspects of performance on campus that is tracked every month. Some of the predominant components in the report include background of the child, history of the medical conditions, identified areas of deficit, identified skills and competencies, immediate and annual goals set that enable him to overcome a problem, levels of interaction with classmates, special education services if any required etc.

Learner Need Analysis (LNA) based on data derived from case study:

Learning needs analyses are undertaken to determine the gap between the existing skills, knowledge, and abilities and those desired. Once this gap is determined, decisions can be usually taken as to the type of training required.

Using the data in the case study, a learner needs analysis. The key elements covered in an LNA include identifying the strengths, weaknesses and differences between the learners, their preferred learning styles, and motivation for learning. The information gathered from the case study through observations and IEP will help give an overall picture of areas that students are good at and some areas they need additional help or special guidance. A thematic analysis was done to identify the strengths and weaknesses of the sample and the same is classified as below:

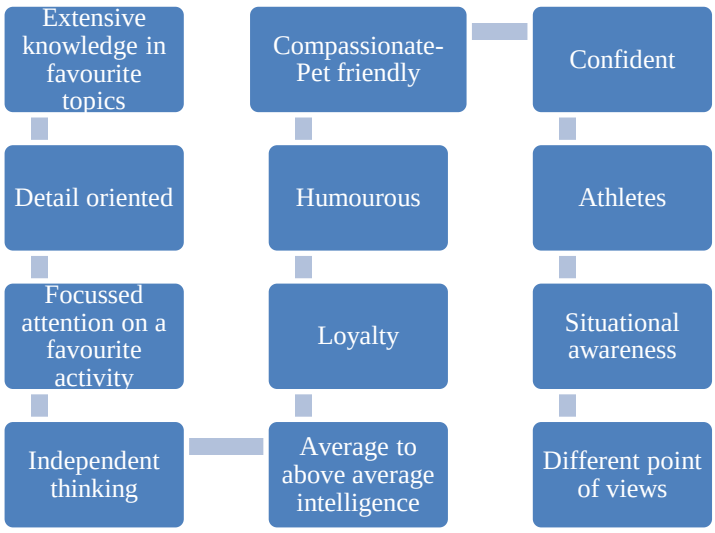


Figure 2 representing the summarized strengths generated through the Learner Need Analysis.

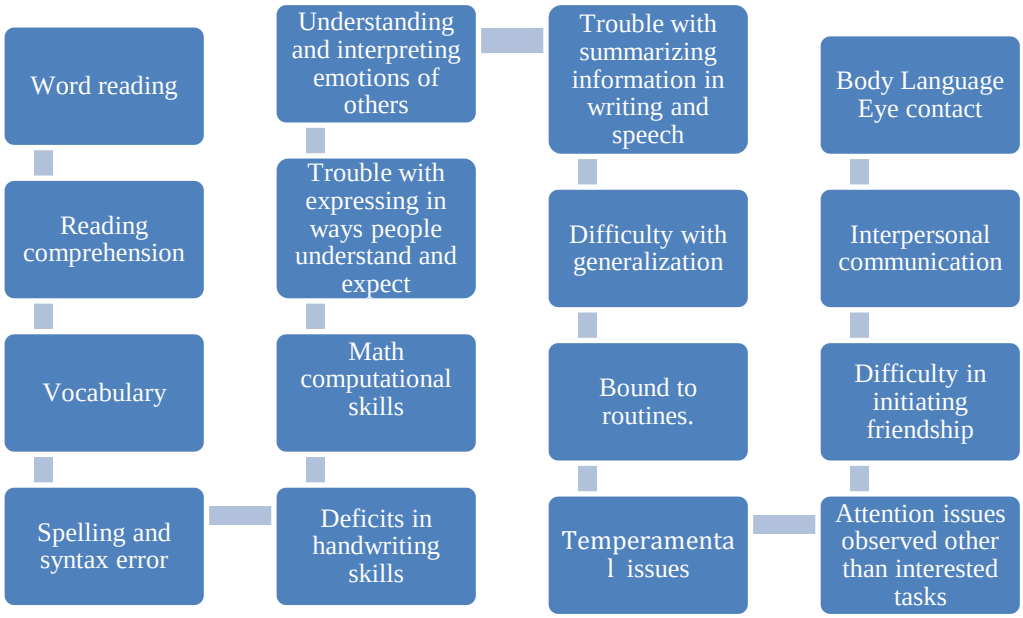

Word reading
Reading comprehension
Vocabulary
Spelling and syntax error
Deficits in handwriting skills
Math computational skills
Trouble with expressing in ways people understand and expect
Understanding and interpreting emotions of others
Trouble with summarizing information in writing and speech
Difficulty with generalization
Bound to routines.
Temperamental issues
Attention issues observed other than interested tasks
Difficulty in initiating friendship
Interpersonal communication
Body Language Eye contact

Figure 2 representing the summarized weakness generated through the Learner Need Analysis.

Studies have shown children with ASD tend to like science fiction, anime, and visual games. Depending on the spectrum they fall, they may even write their own stories, create costumes or be a part of science fairs. They develop and sustain an area of interest and continue to research and indulge in self-guided learning, hence being aware of what is happening around through independent thinking. Visual and rule-based thinking, focused interest areas are their key strong areas. This is largely because students with ASD are known to be visual learners. Information is the form of visuals that often stays longer and is concrete than the spoken and heard information. They indulge in a rote learning where small chunks of information are learnt by heart. They excel in tasks that involve rote learning, physical manipulation, short term memory and visual spatial skills.

Observation method

The researcher observed up to 30 hours of specialized training program offered to students with mild ASD from Grade 10 to 12 by experts. The sessions on enhancing communication and social skills conducted by select teacher and the humanoid robot were observed to assess the effectiveness of humanoid robots on their skill enhancement. Through this training children with autism were given some social skills training that can help them to understand themselves and participate in their community.

The syllabus for the social skills program designed in collaboration with the special needs department. After the completion of the observation method, the observers rated the performance of the students in the Social Communication Scale on a weekly basis keeping track of the progress made by both the teacher and robot. The progress in the social and communication skills of the autistic students in the classroom under the presence of a teacher versus the humanoid robot were assessed using the items listed in the instrument. The Inter rater or Inter observer reliability was adopted to estimate the reliability of the responses noted/scores allotted by the raters for each item. Through this approach, it was seen there was high interrater agreement implying the ratings given for the items in the scale were accurate. It was evident that there was some degree of agreement on the positive impact the humanoid robot had over the class's social and communication skill as opposed to traditional teaching.

Using the scores allocated by the raters, a paired T test method was used to assess the pre and post observation scores derived from the one group design. Items from the Social Communication Questionnaire Scale tested to evaluate the extent to humanoid robots positively impacted the social and communication skills of students with mild ASD. The analysis was done in accordance with the objectives of the study.

Table 2 showing acceptance and rejection of hypothesis

PAIRED OBSERVATION ***Null Hypothesis***: There is no significant difference in the social and communication skills of the select population. ***Alternative Hypothesis (H1):*** There is a significant difference in the social and communication skills of the select population.				
Hypothesis (H1)	**Statistical Test Conducted**	**Values**	**Significant or not**	**Accepted or rejected**
She/he uses socially inappropriate questions/statements.	Paired sample t-test	.024	Significant	Alternative Hypothesis (H1)- Accepted Null Hypothesis- Rejected

Her/his facial expression usually seems appropriate for the situation zas far as one can tell.	Paired sample t-test	.053	Not Significant	Alternative Hypothesis (H1)- Rejected. Null Hypothesis- Accepted
She/he has particular friends or a best friend.	Paired sample t-test	.000	Significant	Alternative Hypothesis (H1)- Accepted Null Hypothesis- Rejected
She/he talk with others just to be friendly (rather than to get something.	Paired sample t-test	.000	Significant	Alternative Hypothesis (H1)- Accepted Null Hypothesis- Rejected
She/he spontaneously copies other people and what you are doing	Paired sample t-test	.002	Significant	Alternative Hypothesis (H1)- Accepted Null Hypothesis- Rejected
She/he spontaneously point at things around her/him just to show things (not because she/he wants them).	Paired sample t-test	.000	Significant	Alternative Hypothesis (H1)- Accepted Null Hypothesis- Rejected

She/he use gestures, other than pointing or pulling hand, to let one know what she/he wants	Paired sample t-test	.000	Significant	Alternative Hypothesis (H1)- Accepted Null Hypothesis- Rejected
She/he nod her/his head to mean yes	Paired sample t-test	.006	Significant	Alternative Hypothesis (H1)- Accepted Null Hypothesis- Rejected
She/he shake her/his head to mean no	Paired sample t-test	.082	Not Significant	Alternative Hypothesis (H1)- Rejected. Null Hypothesis- Accepted
She/he usually look at the person directly in the face when doing things with them or talking with them	Paired sample t-test	.000	Significant	Alternative Hypothesis (H1)- Accepted Null Hypothesis- Rejected
He/he smile back if someone smiles at her/him	Paired sample t-test	.016	Significant	Alternative Hypothesis (H1)- Accepted Null Hypothesis- Rejected

She/he show things that interest her/him to engage others attention	Paired sample t-test	.016	Significant	Alternative Hypothesis (H1)- Accepted Null Hypothesis- Rejected
She/he offers to share things other than food with others	Paired sample t-test	006	Significant	Alternative Hypothesis (H1)- Accepted Null Hypothesis- Rejected
She/he seem to want others to join in her/his enjoyment of something	Paired sample t-test	.006	Significant	Alternative Hypothesis (H1)- Accepted Null Hypothesis- Rejected
She/he ever try to comfort others if they are sad or hurt	Paired sample t-test	.016	Significant	Alternative Hypothesis (H1)- Accepted Null Hypothesis- Rejected
When she/he wants something or wants help, she/he look at the person and use gestures with sounds or words to get their attention	Paired sample t-test	.016	Significant	Alternative Hypothesis (H1)- Accepted Null Hypothesis- Rejected

She/he show a normal range of facial expressions	Paired sample t-test	.000	Significant	Alternative Hypothesis (H1)- Accepted Null Hypothesis- Rejected
She/he play any pretend or make-believe games	Paired sample t-test	.167	Not Significant	Alternative Hypothesis (H1)- Rejected. Null Hypothesis- Accepted
If a teacher comes into a room and start talking to her/him without calling her/his name, she/he usually look up and pay attention to them	Paired sample t-test	.002	Significant	Alternative Hypothesis (H1)- Accepted Null Hypothesis- Rejected
She/he plays imaginative games with another child in such a way that a third person can tell that they each understand what the other is pretending	Paired sample t-test	.167	Not Significant	Alternative Hypothesis (H1)- Rejected. Null Hypothesis- Accepted
She/he plays cooperatively in games that need some form of joining in with a group of other children, such as hide-and-seek or ball games	Paired sample t-test	.006	Significant	Alternative Hypothesis (H1)- Accepted Null Hypothesis- Rejected

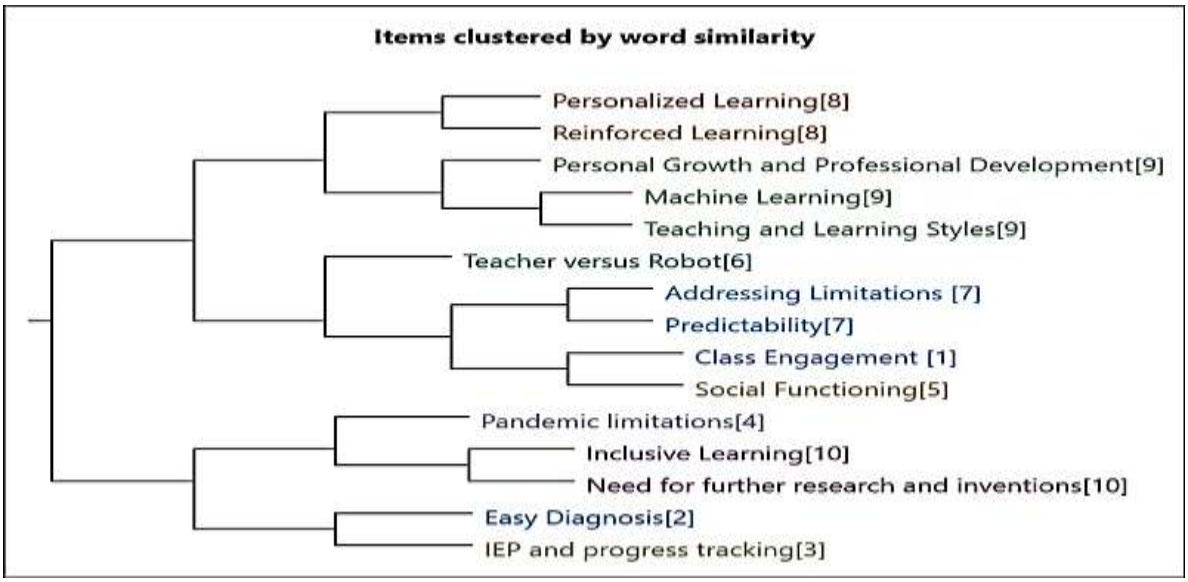
From the above table, it can be inferred that there has been a significant difference in following areas:

i. Understanding friendship, trust and being able to make a friend in class.
ii. Talk with others in class just to be friendly indicating improved confidence and progress towards social communication skills.
iii. Spontaneously copies other people or what they are doing (such as vacuuming, gardening, or mending things) to learn new socially accepted behaviors and routines.
iv. Students can call out for help from their peers and teachers by pointing at things, using gestures and words.
v. Look at others directly in the face when doing things with them or talking with them.
vi. Nods and responds to people instead of shying away or appearing distant.
vii. Smiles back at people instead of looking back and forth from objects to people.
viii. Takes interest in showing other things that interest her/him to engage their attention.
ix. Despite possessing atypical eating behaviors, they are able to share food with others and comfort their peers/friends thereby signaling social intimacy.
x. Shows a normal range of facial expression in social/classroom settings which is crucial for social interaction.
xi. Looks up to the teacher and robot and pays attention instead of hiding his/her face or avoiding eye contact.
xii. Engages in games that require collaboration and co-operates with peers under the supervision of families, teachers, and robots.
xiii. However, it can be seen the sample continues to pose socially inappropriate questions or statements. For example, regularly asking personal questions or making personal comments at awkward times.

Semi Structured Interviews

Table 3: Representing the sample specificities of the expert interview

Nature of the sample	Sample size	Region
Special Tutors	14	Bangalore
Psychotherapists/ Counselors	6	Bangalore



Figures 4 representing the key themes that emerged from interviews

Table 4: Major themes and codes generated from analysis of the interview data

Major Themes	Codes	Frequency	Prevalence
Features	Long term attention	11	13
	Judgement	14	18
	Gamification	13	25
	Modeling behaviors	18	24
	Eliminates the human element	22	20
Design	Eye Gaze	15	26
	Touch	12	18
	Eliciting Behavior	15	21
	Self-presentation	11	57
Student Centered Classroom	Self-Stimulatory Behaviors	5	10
	Constructivism	4	6
	Customized	25	345
	Collaboration	6	6
	Meaningful interactions	13	29
	Inclusion	19	55
Psychosocial Needs	Consistent & Predictable	25	179
	Engagement	12	18
	Applicability quotient	15	31

	Overshadowing existing relationships	2	2
	Positive reinforcement	16	21
	Judgement	22	44
	Motivation	20	25

Focus group discussion

Table 5: Profile of the parents who participated in the focus group discussion

Sl No	Parent Name	Parent of	Employment	Age
1	*Varun John*	*JC*	*Working*	*51*
2	*Akhil Gunasheelan*	*GG*	*Working*	*51*
3	*Smitha Shravan*	*RS*	*Working*	*47*
4	*Shruti Modi*	*MD*	*Homemaker*	*52*
5	*Devyani Hariharan*	*PH*	*Working*	*50*
6	*Venkatesh Arun*	*PV*	*Working*	*44*
7	*Anu Menon*	*AM*	*Homemaker*	*55*
8	*Ganga Tripati*	*VK*	*Homemaker*	*53*
9	*Meghana Jayaram*	*SJ*	*Working*	*52*
10	*Emma Sebastin*	*AS*	*Working*	*46*

Table 6: Matrix assessing the level of verbal consensus in the focus group along with principal questions

Focus Group Question	All respondents giving consensus (%)
How is your child responding to online classes during the lockdown phase?	100%
Are there any challenges that children with special needs encounter in such modes of learning?	100%
Do children miss the classroom setting and the robot teaching?	100%
What is the kind of skills and competencies developed during this remote learning?	100%

Are these classes tailormade to meet your children's learning needs?	100%
Is your child proactive and interacting during these online classes?	100%
What are the differences you perceive in the way a child learns from a robot and a teacher?	100%

Before the above set of questions were given to the sample for discussion, the moderator made sure the environment was non-evaluative thus making members in the group feel free to have their feelings and opinions expressed without any fear of agreement or disagreement from other members in the group.

Leads offered by the participants were further probed by the moderator with additional questions based on the kind of responses that were derived from the sample's end. While some of the information have been represented in a matrix, it is to be noted that the information is put down in a manner that is easy to assess. Though some of this information can be numerically summarized, the researcher has taken into consideration the rich context in which the respondents' words are embedded with additional meanings.

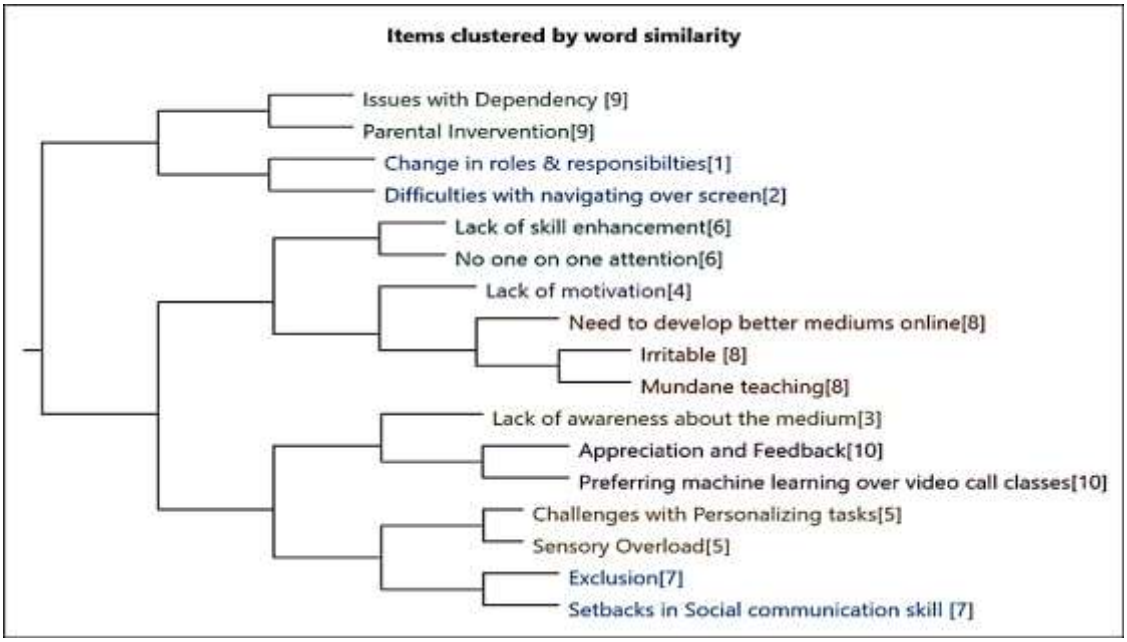

Items clustered by word similarity
Issues with Dependency [9]
Parental Invervention[9]
Change in roles & responsibilties[1]
Difficulties with navigating over screen[2]
Lack of skill enhancement[6]
No one on one attention[6]
Lack of motivation[4]
Need to develop better mediums online[8]
Irritable [8]
Mundane teaching[8]
Lack of awareness about the medium[3]
Appreciation and Feedback[10]
Preferring machine learning over video call classes[10]
Challenges with Personalizing tasks[5]
Sensory Overload[5]
Exclusion[7]
Setbacks in Social communication skill [7]

Figure 5: Matrix representing the themes narrowed down from the group discussion.

Validation Process

Interviews: Seventeen questions were initially drafted for the interview. Post validated from Joseph B Ryan, Ph. D in Special education and Distinguished professorship for Clemson LIFE, a list of 11 questions were finalized for the study. Dr. Ryan expertise lies in the field of Educational Technology and Special Educational Needs. Additionally special tutors in leadership and research roles from the current academic institution validated the questions. Sample interviews were also conducted to check the nature and quality of responses before executing the research design with the sample group.

Focus Group Discussion: 7 questions were framed as part of the focus group discussion with parents of the students with mild ASD. These questions were also validated by Dr. Joseph Ryan along with counselors from the institute. Based on the feedback and insight from the reviewers, each item in the initial draft was modified in ways to capture one idea, emotion thought for each question. To avoid researcher's personal bias, skilled moderators were roped for the focus group discussion. Notes from all the moderators were compiled for the study to further validate the key findings.

Social Communication Scale: The SCQ is a prominent and well-known scale used in school settings by clinicians and special tutors to periodically evaluate the communication and social functioning of children specifically with autism spectrum disorder. A copy of the instrument (teacher version) updated by NHS Foundation Trust, Central and Northwest London and under the possession of Prof. Hesi Hebert, Department of Psychology, Christ University was used for the study. No modifications were made in the scale as all items appeared relevant and applicable to the study.

FINDINGS

The instrumental case study method was conducted as part of exploratory research, to gain a multifaceted understanding, concrete and contextual information about the strengths, problems and limitations faced by the select sample. The data was gathered through observation of students in classroom settings and gaining access to clinical records of each student maintained by the counselor. To eliminate researcher bias, moderators were involved in the study to observe the same sessions. The data gathered from moderators and researcher's notes was repeatedly studied and analyzed to narrow down specific academic and behavioral strengths, along with areas of

concerns that further contributed to designing relevant research designs necessary to take the study forward. The results showed all the students diagnosed with mild autism spectrum having limitations in the following areas: self-expression, collaboration, critical thinking, attention, perception, retention, empathizing with peers, reading and comprehension, language skills, interpersonal communication, classroom interactions, sociability, non-verbal communication, motor skills, maintaining appropriate body language, eye gaze, feeling anxious around group of people, understanding and exercising socially appropriate behaviors etc. However, the students also showed interests in storytelling, game-based learning. Most of the children maintained a hobby and showed sustained interest in music, technology and while some showed interest in taking up responsibility of a grooming and caring pet.

To examine the effectiveness of humanoid robot interventions in classrooms to assist students with mild autism through their social interactions, a social skills training program was created by the school along with inputs from experts to help the sample with their social and communication skills. The modules were also designed keeping in mind the goals that required attention as per the Individual Educational Plan devised for each student with special educational needs. The program was conducted by licensed special tutors under the supervision of counselors at first followed by the robotic intervention. From the observation, it was evident that students gradually felt very comfortable being around the robot over the course of time and there was positive child-robot interaction taking place. Attention span was better during the robotic intervention when compared to the teacher led session. Children were able to maintain some eye contact, physical contact and impersonate the actions as demonstrated by the robot. Students were seen distracted and hesitant in the presence of the teacher and required several prompts and guidance by the instructor to model the actions.

The observational notes of the training program were rated using the Social Communication Questionnaire (SCQ) and the score allotted for each item in the scale was quantified using the paired T test method. Inter-rater reliability was additionally used to test the reliability of the response and arrive at an inference. The raters' results were fed into SPSS, T test was adopted to tabulate the results for the study. The T test showed some improvements mostly in the verbal, non-verbal communication, and social behavior of children with mild autism. All children selected as part of the sample interacted moderately with the robot which was not the case and would have been

challenging in a teacher lead classroom. In general, the observation of the social skills program showed the robots acting as social agents stimulating social skills showing improvements in the following areas- touching, imitation, eye contact and seeking help. Prior studies in this field have also shown 1-1 child robot interaction posing numerous learning benefits along with some skill development.

After the social skill program intervention, the IEP reports maintained by the counselors and special tutors showed improvements in areas goals were set. Goals were achieved better due to the efficacy of the intervention which was not the case in a traditional classroom setting. The course conducted by teachers showed challenges, slow progression and requiring more hand holding even after the program while robotic intervention was able to meet goals and fill the gaps within the allotted period.

The interviews with special tutors and counselors closely working with the sample group and humanoid robot shed light on their perspectives on the use of humanoid robots in delivering support in the areas of communication and socialization. Teachers and counsellor resort to robotic interventions to resolve behavioral problems. Humanoid robots can reduce anxiety and stress caused usually by being around students, faculty in traditional classroom settings. Hypersensitive behaviors and low motivation are common problems recorded among students with autism and developments in these areas have been recorded through the exposure to this emerging technology. Teachers maintaining the IEP reports have recorded evidence of several students' social and communicative skills greatly improving with the introduction of this technology, while the effectiveness of the teaching and the rate of progress have been slower with a human tutor.

As a result of this, some success can be seen in improving the quality of life and instilling skills required for the future if the potential of this technological medium is tapped. Tutors are heavily relying on using this medium to help students with autism attain not only their academic goals but gain skills that can equip them for the future and prepare them to seek some good employment opportunities. This makes it a potential area for research to explore the vast subsidies it can offer in the field of special education.

Parents of the chosen sample group in the focus group discussion shared their perspectives on the use of humanoid robots in delivering support in the areas of

communication and socialization. They enlightened the researcher about the application of experiences, skills learnt during social skills training program with the humanoid robot (transfer skills). Children were able to apply some of the learning in the real-world scenario, some positive changes were noted by parents in social settings. Children were able to maintain eye contact and greet or reciprocate with family members included members from extended families. However, parents admitted to children feeling awkward when required to empathize, reciprocate feelings, and understand the emotional state of members at home. While children could understand facial and emotional expressions, there were certain challenges with responding to such emotional state and settings. While there were some improvements noticed in the social and communication skills, there appeared to be a lag, setback with responding to emotions.

Limitations:

Given the small sample, the point of views of the educators, therapists and parents in this study may not completely reflect the views of educators in other schools. The findings are contextual in nature and may hold relevance to other educational settings if institutions have the funding and resources it takes to invest in a humanoid robot. Designing specific technological interventions can be expensive and time consuming.

Secondly, there is a lot of stigmas associated with disabilities and parents are apprehensive of putting children through any study or experiment despite the study holding good intentions. It was observed children with developmental disorders and intellectual disabilities rely on the love and care of their parents due to which they are frequently not exposed to social settings due to the limitations.

CONCLUSION

The advancements in robotics technologies in the field of special educational needs has shown positive cognitive and social development in children with special needs. With an ability to decrease difficulties, high level of interactivity and personalized functions. Several studies have suggested use of robotics for children with ASD to increase motivation and build cognitive and affective competencies.

The current study connects with the theoretical framework of Media Richness Theory, Computer Mediated Communication and settles the reliability of the

technological acceptance model. Robots are integrated into education due to the levels of personal focus it can offer. The contents delivered by educational robots are engaging and dynamic in nature thereby promoting the retention of information. Educators have shown keen interest in using such a medium to keep students engaged in the learning process. According to the findings in the study, it can be inferred that social robots offer ease of use along with perceived usefulness benefiting the academic institution. The sample consisting of students, special tutors and parents have shown a positive outlook towards the use of Eagle 1.0, the educational robot in building skills and competencies that prepare this section for the future. It can be said humanoid robots can be a potential platform to train competencies amongst children with disabilities due to its ability to reproduce and deliver information to suit the learners' needs

Prior studies have shown the suitable use and potential of small sized robots Maria, Milo, Kaspar, Nao that were used by speech therapists and educators to build communication and comprehension competencies among children with autism. It is evident that robots integrated into current educational practices and special education settings can empower children with learning disabilities to challenge and gradually overcome barriers and help the teacher with effective delivery of instruction. The course content can be designed in ways that meet specific learner needs using robotic interventions which would be challenges in traditional classroom settings. The data obtained from the quantitative and qualitative data confirm that there was positive child-robot interaction with improvements seen in the context of social and communication skills.

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APPENDIX A- LIST OF PUBLICATIONS.

Scopus:

1. Philip, L. (2021). An exploratory study on the representation of transgender characters as disgraceful and disabled beings in gaming media. *Journal Of Tianjin University Science and Technology*, *54*(11:2021). doi: 10.17605/OSF.IO/VBG3W

2. Philip, L. (2022). Teaching Special Education during the COVID-19 Pandemic: An Exploratory Study. *World Journal of English Language*, *Vol 12*(Issue 1). https://doi.org/https://doi.org/10.5430/wjel.v12n1p246

3. Philip, L. (2022). Growing popularity and impact of food-related visual and social media content. *Central Asia and The Caucasus, Volume 23*(Issue 1), 1-25. https://doi.org/https://doi.org/10.37178/ca-c.23.1.01

Other Publications:

Leena Philip, M. B. (2019). An exploratory study tracing the impact of ICT enabled education among students with autism spectrum disorder in Bengaluru. *Changing Dimensions in Media: Looking for New Paradigms* (pp. 500-514). Bengaluru: http://conferenceworld.in/Conference.php?cID=1275.

Leena Philip, S. K. (2019). A study on the use of social media as a disaster management tool in India. *Changing Dimensions in Media: Looking for New Paradigms* (pp. 123-132). Bengaluru: http://conferenceworld.in/Conference.php?cID=1275.

Philip, L. (2019). The Representation of The Fantasy and Ideal Body Image: A Study of Female Protagonists in Disney Movies. *Changing Dimensions in Media: Looking for New Paradigms* (pp. 393-408). Bengaluru: CMS.

Philip, L. (2018). An analysis of excellence among pr agencies in Bengaluru. *International Journal of Basic and Advance Research*, 165-172.

Leena Philip. (2017). Corporate Blogging: The New Age PR Tool. *European Journal of Interdisciplinary Studies*, *3*(3), 65-69.

APPENDIX B- LIST OF CONFERENCES.

National:

1. The Representation of Transgender Characters in Popular Media": National Conference on Gender and Media: Reva University, 2018.
2. "Social Media as A Disaster Management Tool During the Kerala Floods": National Conference on Traditions and Transitions of Ethical Concerns in Digital Media: Kannur University, 2019.
3. "An Exploratory Study Tracing the Impact of ICT Enabled Education Among Students With ASD": National Conference on Media and Society: Jain University, 2019.
4. Symposium: Managing Diversity in the classroom under the RTE presented jointly by Sampurna Montfort & Drishti, 2020.

International

1. "Study on The Character Representation of Female Protagonists in Hindi Cinema": *International* Conference on Gender Narratives: Garden City College, 2018.
2. Remote Learning in Special Education During the Covid 19 Pandemic: An Exploratory Study: Media Meet 2020 - an *International* Virtual Conference: CHRIST (Deemed to be University), August 27th and 29th ,2020.
3. Challenges faced by special tutors in designing quality online learning material for students with special needs during the COVID-19 lockdown, *International* Conference on Post COVID Management Strategies: Recovery, Resilience, and Adaptation: IIM Bodh Gaya organized, April 23rd and 24th ,2021.
4. "Representation of Refugees and Migrants: An Exploratory Study on The Changing Media Narratives": *International* Conference on Socio Economic Implications of Transnational Migration: Sir Syed University, Kannur, 2019.
5. School 21 Century-National Ideation Colloquium: Indus International Ideation Colloquium: Indus International School, Bangalore, 2021.
6. "Prototype for the Schools of the Future": Indus International Ideation Colloquium: Indus International School, Bangalore, 2021.

APPENDIX C- ETHICAL CLEARANCE FORM BY RCEC

CHRIST
(DEEMED TO BE UNIVERSITY)
BANGALORE · INDIA

CENTRE FOR RESEARCH

CU: RCEC/00221/08/21 05 August 2021

Ms Leena Philip
Reg No: 1730076
CHRIST(Deemed to be University)

Sub: Approval of the Study Titled "Role of Humanoid Robots In Enhancing Communication And Social Skills Among Students With Mild Autism."

The Research Conduct and Ethics Committee has reviewed your application for ethical clearance for the Study titled "Role of Humanoid Robots In Enhancing Communication And Social Skills Among Students With Mild Autism."

The Proposal is

Exempt from review.

~~Expedited for review and the result will be intimated in two weeks.~~

~~Recommended for full review and the results will be intimated in three weeks.~~

Additional Comments: Nil

The researchers are encouraged to disseminate the findings of the research in a suitable form to the beneficiaries and participants of the research and a copy of the same sent to the RCEC.

Sincerely,

T.S. George

Tony Sam George
(Member Secretary to Research Conduct and Ethics Committee)
Center for Research
CHRIST (Deemed to be University)
Bengaluru- 560029

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APPENDIX D - CONSENT FORMS

INDUS
INTERNATIONAL SCHOOL

Permission Letter

Consent for Observation

Ms. Leena Philip, PhD Research Scholar at Christ University has my permission to participate in the educational and research projects at Indus (MYP-DP) School that utilize observational research techniques.

We have students have special educational needs, particularly the one's observed are children with mild autism spectrum disorders who very often face environmental-behavioral challenges. Hence, no permission will be granted to videotape or be videotaped with the sole intention of respecting the parents concern, management protocols and student's personal space in such special cases, to avoid unexpected outbursts.

Ms. Leena will be visiting the SEN classrooms at least 4 times over two semesters (September 2019-March 2020) in consultation of the teachers. This is for the sole purpose of learning more about student's academic record, holistic development and class engagement before and after the intervention of Eagle 1.0.

All observations will only note children by initials or some other anonymous designator to guard their confidentiality. If a paper is to be published or presented in any professional forum, I would like to be consulted with a separate consent form for such projects. I retain the right to withdraw my permission at any time.

Dr. JYOTI PATIL, MBBS, MD,
Medical Officer
Indus International School
Bangalore

Signature of Medical Officer